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# Reduced Tool Wear

*Coolant improves surface finish and extends tool service life in machining aluminum alloys*

Jürgen Geke and Henry Roßmaier

The new high-performance coolant P3-multan 97-10 (D) brings economic efficiency to aluminum alloy machining processes while providing unsurpassed surface quality and reliability of performance in both hard and soft water. In the development of this coolant, diverse requirements were taken into account to set it apart from other commercially available products. For one, its boron-free formula exhibits a high bacterial stability. This property, apart from reduced ecotoxicity, is associated with process technology benefits since it prevents the formation of tacky residues on tool changers, sensors or machine tools.

In finishing bores in steering gear housings with a single-edge PCD reamer, an average surface roughness of 1.9 mm was achieved with the new coolant - as distinct from about 8 µm with a conventional product.

As a result, this coolant is also suitable for grinding operations. Moreover, it contains no phosphorus, sulfur or chlorine compounds. The formula is semi-synthetic, with the oil portion consisting of mineral oil and vegetable oil – a particularly favorable mixture from the viewpoint of optimizing surface finish and tribological efficiency.

## Different water hardness versions

To ensure the availability of this coolant's full advantages regardless of water hardness it is available in two versions: P3-multan 97-10 for soft water from 0-5 °dH (0 – 50 ppm CaO), and P3-multan 97-10D for

hard water from 5-40° dH (50 – 400 ppm CaO). The anti-corrosion behavior of coolants is assessed electrochemically with a view to protecting iron and steel workpieces in intermediate storage – and unlike standard coolants, this product permits such in-process storage periods. These results are confirmed by climate testing of plate specimens at various relative humidities. Experience shows that these findings coincide well with actual product behavior.

The discoloration inhibiting effect in light metals is determined via standard piston manufacturing and/or aerospace industry tests. No discolorations were observed on pistons made of high-silicon aluminum alloys; the same holds true for brass chips (Fig. 1). Favorable results in the modified Boeing test, the aerospace industry's clearance test, complete this picture. All requirements are fully met. Carried out with AlMg3Si0.5Cu2, AlMg3Si0.1Cu2.6 and AlMg2Si0.5Cu4.9, this test comprises a 14-day immersion in an 8% emulsion, a 14-day copper test, as well as a 21-day contact corrosion (sandwich) test.

Fig. 1

No discoloration was observed on a piston made of high-silicon aluminum alloys.

The key parameter in coolants is tribological performance. Shape tolerance and surface roughness measurements carried out with coolants from various manufacturers at Cetim, the French research institute, showed outstanding results for the P3-multan 97-10 product with booster additive. The low average peak-to-valley height $R_z$ and the low average roughness $R_a$ lend further credence to these findings (Fig. 2). Tapping torque measurements – in which a low result reflects a low force input, i.e., less tool wear – yielded the best results for P3-multan 97-10D in tests against standard commercial products (Fig. 3). Steel fretting tests per DIN 51834 – where, again, a low friction coefficient stands for low tool wear – showed P3-multan 97-10D to be at least equivalent to a standard steel cutting coolant. The effectiveness of the P3-multan 233 booster, which contains organic active ingredients for improved metal removal performance, was likewise confirmed. A significantly higher test force was achievable (Fig. 4).

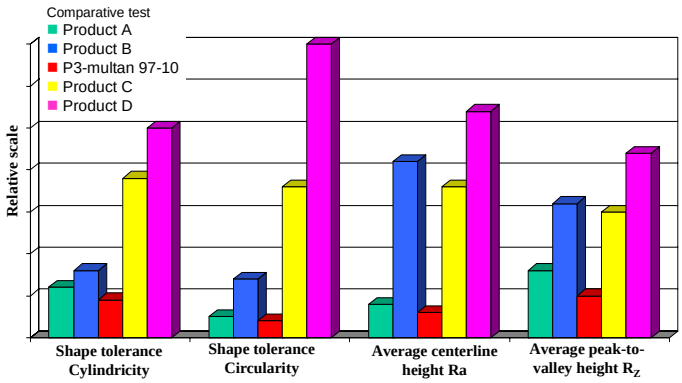


Fig. 2
Relative shape tolerance and surface roughness results obtained with different coolants (material: AlSi6Cu3Mg, tool: PCD-coated reamer, 10.5 mm dia., cutting speed: 235 m/min, 7120 r.p.m.)

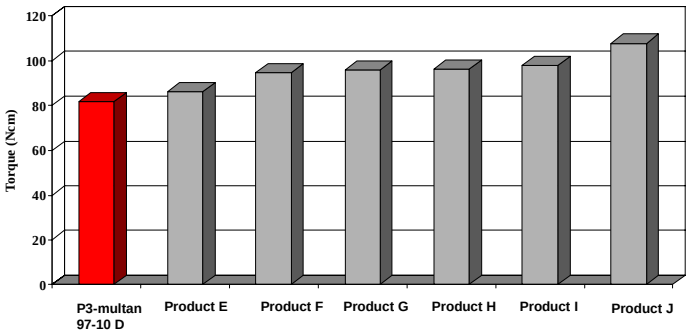


Fig. 3:
Tapping torque tests

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|---|---|
| Concentration: | 5% emulsions |
| Material: | AlMgSi |
| Tool: | M6X1HSS |
| Spindle speed: | 600 $min^{-1}$ |

Torque calculated as an average of 6 measurements

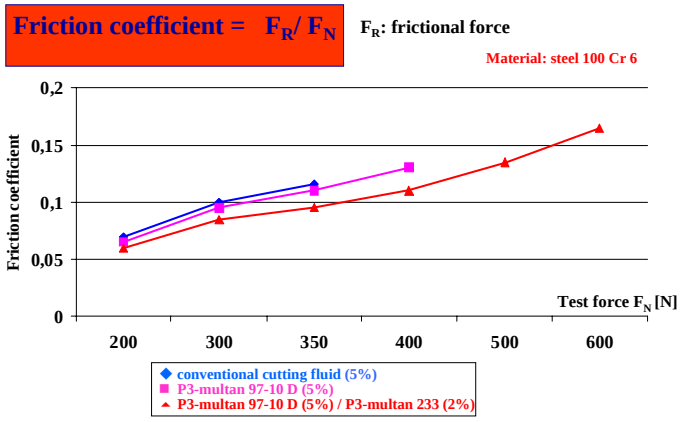


Fig. 4:
Coefficients of friction as measured with different coolants
(variable test force, test conditions: temperature 35°C, test frequency 50 Hz, oscillation amplitude: 1 mm)

On principle the new coolant is suitable for all types of materials and machining operations. It covers a wide range of metal processing applications, including uses in the automotive and components industry. The list of products extends from steering units, electric motor housings, printing press parts, camshafts, door hinges and eccentric shafts to transmission components and housings, clutch systems, wheels, bowls, brake disks and hydraulic systems including tubes, where the new coolant is used in a flow turning process. It also gives good results in use in water hydraulic systems and in machining of copper. The spectrum of materials on which it can be used includes all relevant iron and steel alloys, non-ferrous metals and, above all, light metals.

Aluminum materials, from easy-to-machine alloys such as AlSi10Mg (artificially aged) to the most difficult ones such as G-Al-Cu4Ti (naturally aged, artificially aged), are of particular interest in this context. On soft aluminum alloys, edge build-up during machining can be fully suppressed by adding the P3-multan 233 booster.

**A coolant suitable for all cutting materials**

The range of cutting materials extends from unalloyed and alloyed tool steels to highly alloyed high-speed steels, in part with titanium coating. It also includes hard metal and, harder still, ceramics, with very high grade multilayer cutting materials comprising layers of polycrystalline diamond (PCD) or cubic boron nitride (CBN) rounding out the spectrum. All tool materials, without exception, can be used with this coolant system with outstanding economic efficiency in nearly all machining processes, whether circular or surface grinding, drilling, deep hole drilling, boring, turning, milling, tapping, thread milling, flow turning, or reaming with single-edge reamers.

Two examples from the field of aluminum processing may illustrate the performance of the new coolant. In finishing bores in steering gear housings with a single-edge PCD tipped reamer (concentration: 7% P3-multan 97-10 D instead of 13% of a competitor product, material: GD-AlSi9Cu3, bore specification: 43H8, length 230 mm, machine: two-spindle Honsberg Lamb Mach 1HSC, speed: up to 16,000 r.p.m.), a markedly improved surface finish was obtained. The average peak-to-valley height Rz was 1.9 µm, versus about 8 µm achieved with a competitor product.

**Twenty percent tool life increase in machining alloy wheels**

The manufacture of aluminum alloy wheels is a growth segment in the automotive components industry. Continuing demand for ever more lightweight designs has boosted the production of these cast aluminum products. In turning aluminum alloy wheels of AlSi7Mg (wheel dimensions: 6.5 x 16", 9.5 mm wall thickness) on a lathe using round reversible carbide tips, the use of P3-multan 97-10 (concentration: 5%, spray application/minimum quantity lubrication) yielded a significantly

more accurate tyre seat compared with the conventional coolant used previously – an effect attributable to the reduced rim well temperature. The service life of the reversible tips increased by at least 20%.

It thus became possible to meet specified tolerances over a production run of 50 to 65 wheels instead of the previous maximum of 25 to 45. In both processes, the economic efficiency achieved is attributable to the high-grade surface finish, long tool life, and low coolant consumption.

The machined products pass a number of cleaning and pre-treatment baths in the further processing sequence. Optimum results are achieved with an integrated process management, for which this high-performance coolant – with its emulsifier, corrosion-inhibitor and lubricant modules – has been specifically rated. The P3-emulpon 97-10 product, an neutral cleaner used in downstream cleaning applications, is based on the same emulsifier and corrosion inhibitor modules. The advantages of this approach lie in the high compatibility between machining and subsequent cleaning stages (Fig. 5). The difference between the blue curve (P3-multan 97-10 coolant) and the green one (oil content of P3-multan 97-10) corresponds to the amount which need not be added via the P3-emulpon 97-10 cleaner since it is already made available by carryover of the P3-multan 97-10 emulsion. The experience gathered in a camshaft bearing application in a Swedish auto plant confirms this model.

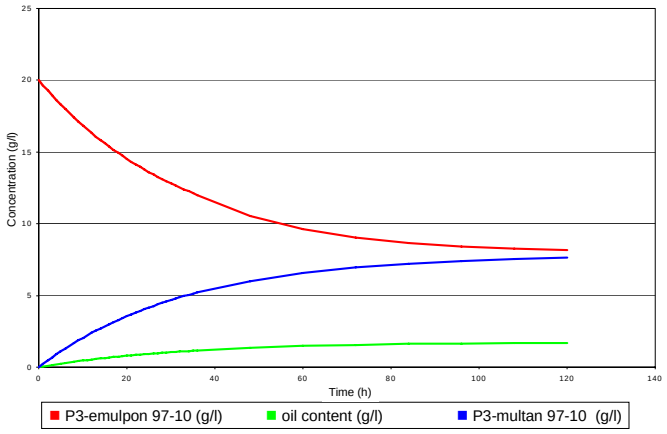


Fig. 5:
The coolant carried over into downstream product cleaning contains the same emulsifier and corrosion inhibitor as the cleaner, reducing cleaner make-up levels.

## Good corrosion-inhibiting properties

The corrosion-inhibiting properties of the P3-emulpon 6771 emulsion cleaner, which is likewise based on the same modular principle, are conclusively demonstrated by cyclic voltammetry, an electrochemical measuring method. The corrosion-inhibiting potential is characterized by low current density peaks. Compared with the standard coolant tested concurrently, these peaks are substantially lower with P3-multan 97-10D, P3-emulpon 6771 and P3-emulpon 97-10, respectively. The suitability of all products for component storage are confirmed by both plate climate tests and practical findings. With P3-emulpon 6771, machined parts can

be kept in storage for several months, even during sea transport in appropriate packaging.

**Finely dispersed emulsion improves run-off behavior**

The modular concept facilitates the consistent implementation of integrated process management systems addressing machining, cleaning and corrosion protection requirements at the same time. Tool life is increased by the system's high tribological performance. The finely dispersed emulsion (average particle size: 180 nm) makes for good run-off characteristics, resulting in low drag-out rates and reduced consumption. Thus, make-up rates are minimized while economic efficiency is augmented. Good rinsing properties reduce the consumption of maintenance cleaners. Ultimately, the required input of disposal chemicals at the waste-water treatment stage is lowered as well. The high cleaning power of the P3-emulpon 97-10 neutral cleaner for maintenance and floor cleaning purposes remains consistently available. Each of these technological benefits provides significant cost advantages by itself, much more so through their combined effect. The environmental characteristics of the new coolant and its modules are favorable. It contains no chlorinated hydrocarbons. Due to the relatively low product concentrations employed, the ecological impact is low. From a toxicological viewpoint the coolant is well tolerated. There is no indication of any health impairment potential in the product. Dermatological studies have shown that none of its constituents is skin-sensitizing.

**CONCLUSIONS:**

- 30% tool life increase
- Cost reduction through low consumption and make-up rates
- Innovative coolant suitable for use in soft and hard water

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Dr.Jürgen Geke is head of Lubricants, Cleaning Products and Water Management Development at Henkel Technologies, Surface Technologies in 40191 Düsseldorf / Germany. Dr. Henry Roßmaier is head of that company's Coolant Development unit. For further information contact Henry Roßmaier on (0211) 2-97-92 03, fax (0211) 798.7900, henry.rossmaier@henkel.de